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ABSTRACT

The interaction of behavioral objectives, sequence order, and test and state anxiety were investigated. The study had four purposes: 1) to examine the effects of objectives on achievement; 2) to investigate the effects of sequencing; 3) to study the interaction of availability of objectives and sequence; 4) to study the effects of objectives and frame sequence on both test and state anxiety. The results indicated that there were not main effects attributal to objectives, and that scrambling frame sequence did reduce achievement and increase program errors. It was expected that providing students with program objectives would have no effect in the logically organized program, but that achievement of students receiving objectives and a scrambled program should be faciliated. This interaction was not supported by the results. As expected, attitudes toward the program were more positive among students taking the logically sequenced material compared to those receiving the scrambled sequence. The fact that state anxiety was unaffected by either objectives or sequence was unexpected. (Author/JK)

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TECH MEMO

BEHAVIORAL OBJECTIVES, SEQUENCE, AND APTITUDE

TREATMENT INTERACTIONS IN CAI

Sigmund Tobias and
Philippe C. Duchastel

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13. ABSTRACT

The interactions of behavioral objects, sequence order, and test and state anxiety were investigated. One of the purposes of the present research was to examine the effects of objectives on achievement. An implicit assumption in most approaches to individualized instruction has been that units, frames, or skills should be ideally sequenced in order to assure optimal achievement. A second purpose of this study was to investigate the effects of sequencing. A further objective of the present research was to study the interaction of availability of objectives and sequence. The final objective was to study the effects of objectives and frame sequence on both test and state anxiety. The results indicated that there were no main effects attributable to objectives, and that scrambling frame sequence did reduce achievement and increase program errors. It was expected that

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ABSTRACT

The interactions of behavioral objects, sequence order, and test and state anxiety were investigated. One of the purposes of the present research was to examine the effects of objectives on achievement. An implicit assumption in most approaches to individualized instruction has been that units, frames, or skills should be ideally sequenced in order to assure optimal achievement. A second purpose of this study was to investigate the effects of sequencing. A further objective of the present research was to study the interaction of availability of objectives and sequence. The final objective was to study the effects of objectives and frame sequence on both test and state anxiety. The results indicated that there were no main effects attributable to objectives, and that scrambling frame sequence did reduce achievement and increase program errors. It was expected that providing students with program objectives would have no effect in the logically organized program, but that the achievement of students receiving objectives and a scrambled program should be facilitated. This interaction between objectives and sequence was not supported by the results. As expected attitudes towards the program were more positive among students taking the logically sequenced material compared to those receiving the scrambled sequence. The fact that state anxiety was unaffected by either objectives or sequence was unexpected.

BEHAVIORAL OBJECTIVES, SEQUENCE, AND APTITUDE TREATMENT INTERACTIONS IN CAI

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The use of behavioral objectives is implicit in most approaches to individualized instruction. Whenever students can go through a program or curriculum at their own rate, the use of behavioral objectives is implied in order to assure that students master equivalent skills. Hence, the use of specific behavioral objectives forms a cornerstone to most innovations in contemporary education. In view of the importance of objectives, it is surprising to note that there is less than uniform research support for the facilitative effect of objectives on achievement. Therefore, one of the purposes of the present research was to examine the effects of objectives on achievement.

Another implicit assumption in most approaches to individualized instruction has been that units, frames, or skills in each curriculum should be ideally sequenced in order to assure optimal achievement. Much attention has been paid in curriculum development efforts toward establishing an ideal order or sequence in which instructional materials are to be presented to students. Again, surprisingly there is little empirical support for the enormous amount of time required to establish an ideal sequence. A second purpose of the present research was, therefore, to examine the sequence question.

A further purpose of the present research was to study the interaction of availability of objectives and sequence. It was reasoned that if objectives facilitate achievement, one mechanism by which this could be accomplished would be by providing an organizational scheme by which the student could more effectively organize the subject matter. Since most CAI programs are inherently well organized, little advantage for objectives was expected in such instances. A scrambled instructional sequence, on the other hand, provides a markedly disorganized stimulus input stream, especially for unfamiliar subject matter. It was reasoned that in a scrambled sequence, objectives ought to increment achievement since they might serve as headings by which unfamiliar subject matter could be more effectively organized. An ordinal interaction between objectives and sequencing of subject matter was thus expected.

The final objective of this investigation was to study the effects of objectives and frame sequence on both test and state anxiety. It was reasoned that students who had objectives available to them ought to be able to organize the subject more effectively, and hence experience less anxiety, especially in the ordered condition, than those without objectives in the random condition.

Behavioral Objectives

A number of studies have investigated whether providing students with the behavioral objectives for the material they are about to learn facilitates achievement . Typically, such designs provide one group of

students with the specific objectives of the lesson to be learned, while another group receives the same lessons without the objectives. The outcomes of these investigations, reviewed in detail elsewhere (Duchastel and Merrill, 1972) have been inconclusive. There are approximately as many studies reporting an achievement advantage for making the objectives available to the student, as there have been studies finding no significant differences attributable to objectives.

One of the conceptions guiding the present study was that objectives are unlikely to facilitate achievement in instructional contexts in which the content is implicitly organized around objectives, whether these are supplied to the student or not. Specifically, instructional contexts such as programmed instruction, CAI, or individualized instruction in which materials have been developed according to a systems or a behavioral model, tend to be relatively free of extraneous subject matter, and tightly focused on the objectives the course of instruction is designed to teach. In these instructional modes, then, the material is implicitly organized around the objectives. Providing the student explicitly with objectives should, therefore, not add anything to the instruction, and hence not facilitate achievement. Instructional context such as lectures, film presentations, or textbooks are typically not as tightly organized around objectives, hence one would expect that providing explicit objectives would enable the student to organize the instructional material more effectively and hence improve achievement.

In the review by Duchastel and Merrill (1972) eleven studies used materials which were programmed in the sense of being presented as a programmed instructional course, a course presented via CAI, or a course presented in an individualized instructional context. Of these nine studies (Smith, 1967; Oswald and Fletcher, 1970; Stedman, 1970; Merrill and Towle, 1971a, 1971b; Conlon, 1970; Etter, 1969; Smith, 1970) found no difference between providing the student with objectives and not doing so. Two studies were described as using materials which were "semi-programmed" (Engel, 1968; Cook, 1969). Of these, one study found a significant difference in favor of objectives, the other did not. The remaining studies reviewed by Duchastel and Merrill (1972) used either lecture, a film presentation, or textbook materials. Half of these found differences in favor of the objectives group, the other half found no significant difference. The description of the materials employed in these studies is not sufficiently clear to permit conclusions regarding the degree to which the materials were tightly organized around objectives.

The preceding analysis of the literature suggested that in a well organized instructional sequence, no difference in behavioral objectives were to be expected. In a scrambled instructional sequence, however, in which the organization of the subject matter has been disorganized, one would expect objectives to allow students to organize the material more effectively, and hence, in such a situation, objectives ought to exert a facilitating effect on achievement. It was the purpose of this study to test that hypothesis.

Sequence

The effect of the sequence in which instructional material is presented to the learner has received some study in the area of programmed instruction. Typically, in these investigations, a program is presented to one group in what is considered a logical, well organized sequence, and to another group with the frame sequence determined by a table of random numbers. Surprisingly, the majority of these investigations, reviewed elsewhere (Tobias, in press; Niederneyer, 1968), have revealed few achievement differences between the random and the ordered sequence. Sequence was studied in a CAI context by Wodtke, Brown, Sands, & Fredericks (1967); no achievement differences attributable to sequence may have been a function of the fact that students had substantial prior familiarity with the content of the programs used. With such familiarity, students would be expected to learn even from a scrambled sequence, in much the same way that using flashcards facilitates achievement. On familiar content the random sequence may serve to review details in a generally well organized body of knowledge. On unfamiliar material, on the other hand, students were unlikely to be able to fit each frame into an organizational scheme of the domain; therefore, it was expected that scrambling frame sequence would significantly reduce achievement on unfamiliar material but not on familiar content. The results confirmed the hypothesis: there were not differences on a familiar program; on an unfamiliar program scrambling accounted for thirty-three percent of the variance and resulted in highly significant differences in achievement. The aim of the present study was to replicate sequence findings in a CAI context.

Interaction with Aptitude and Anxiety

Previous research had suggested that both objectives and sequence might interact with verbal ability. For example, Ausubel and Fitzgerald (1962) found advance organizers to be effective only for subjects of low verbal ability. These results were replicated by Dawson (1965). An interaction between aptitude and objectives was thus expected, such that low ability students with objectives should achieve more, and make fewer program errors than high ability students.

Scholastic aptitude was also expected to interact with sequence. It seemed reasonable that students with high scholastic aptitude should be less disorganized by the scrambled sequence than less able students. Their high ability ought to enable such individuals to search out relationships, reorganize subject matter, and resequence materials as they are processing them to a greater degree than less able students. The scrambled frame sequence in an instructional program should impair these students' achievement and acquisition to a lesser degree than students of lower scholastic ability. Such an interaction was in fact found by Wodtke, et al (1967). In another sequence investigation (Tobias, in press) the expected interaction between sequence and scholastic aptitude was, however, not obtained. It was, therefore, decided to reexamine the question in the present study.

Recent reviews of research on test anxiety (Wine, 1971; Sarason, in press) have indicated that, in evaluative situations, low anxiety students function more effectively than high anxiety students. In this study it was expected that test anxiety might interact with both objectives and sequence. It was reasoned that presenting the objectives

would enable high anxiety students to organize the instructional material more effectively; also that such organization should be further facilitated for high anxiety individuals, especially in the scrambled condition.

Merrill and Towle (1971b) had shown that state anxiety was reduced for groups receiving objectives. It was thus one of the final purposes of this investigation to replicate that finding.

Method

The general design of this experiment consisted of two manipulated variables, objectives and sequences. Two types of anxiety were assessed: test anxiety prior to the beginning of the experiment, and state anxiety obtained during the instructional and test sequence.

Subjects

A total of 119 subjects participated in the study. These subjects were recruited from psychology classes at FSU and received class credit for their participation in the experiment. However, since two subjects failed to complete the posttest, data analyses were performed with an N of 117.

Materials

The instructional material used in this study consisted of the technical part of the program on heart disease developed in previous research (Tobias, 1972a). The materials were in a linear PI format requiring constructed responses and providing feedback. They dealt mainly with the diagnosis of myocardial infarction from the fifth precordial lead of the ECG. Medical terminology for different degrees

of severity of coronary disease, electrocardiographic tracings characteristic of each level of severity, and graphic representations of the damage to the heart muscle caused by the various levels of coronary disease were also included in the program. Certain technical modifications had previously been made to the program in order to adapt it to a CAI mode of presentation. Certain frames for example, required the subject to "draw" ECG tracings. To accomplish this, the subject simply types in on the keyboard a set of numbers, each one of which was associated with a particular part of the drawing. The program contained a total of 80 frames.

The logical sequence of materials was defined as the sequence which was built into the program. The random sequence was established by a table of random numbers.

The behavioral objectives used in this study were developed specifically for this project. They all involved active learner behaviors (what the student should be able to do) and were presented to the students as follows: "After completing the program, you should be able to . . . . (for example) state the technical term for the heart muscle." A total of 25 objectives were developed and are reproduced in Appendix A.

Measures

The dependent measures were achievement on a posttest, learning time, number of errors on the program, and student attitude. State anxiety was also assessed at three points during the study.

Achievement was measured on a revised form of the posttest developed by Tobias (1968). The posttest, administered by the computer at the end of the program, required constructed-response answers and contained 44 items, all directly referenced to the objectives. The maximum score obtainable on the posttest was 60 points. The alpha reliability indices obtained from the postest and the other measures used in this study, are presented in Table 1. The posttest itself is presented in Appendix B.

TABLE 1

Alpha Reliability Indices for the Instruments Described in this Section

Posttest[1]	.80
Attitude - Subscale 1	.71
Attitude - Subscale 2	.87
STAI (state anxiety)	.84

[1]Obtained from previous research.

Student attitude was measured by an attitude scale which consisted of two subscales. The first subscale, which was administered by computer, was a six-item semantic differential scale developed for this study. It attempted to measure the student's reaction to the program with adjectives such as "easy-difficult," "confusing-clear," etc. The second subscale was an instrument used in previous research with the same learning materials (Tobias, 1972b). It consisted of 14 items and was administered via paper and pencil. The total attitude score for each subject was established by adding together his two subscores. Both subscales are presented in Appendix C.

An index of test anxiety was obtained from the Test Anxiety Scale (Sarason, in press). State anxiety was measured by the short form (5-item) A-State scale of the State-Trait Anxiety Inventory (Spielberger, et al., 1969). Finally, general ability, which was one of the main variables in this study, was obtained for each student from the Florida 12th Grade Scholastic Aptitude Test profiles which were available from the University Registrar. The scores obtained were expressed as percentiles.

Apparatus

The program was presented on the FSU CAI Center's IBM 1500 system. Terminals for this system consist of a cathode ray tube and a keyboard. All student responses as well as latencies were automatically recorded by the system.

Procedure

The 119 original subjects were assigned at random to each of the treatment groups. The slightly unequal N amongst treatments resulted from two subjects not completing the posttest.

Upon arrival, the Test Anxiety Scale (Sarason, in press) was administered. Subjects then received a set of mimeographed sheets which included directions for the study and instructions for using the CAI terminal. Subjects in the behavioral objectives groups (B.O. groups) also received a sheet containing the 25 objectives, plus written instructions on how to effectively use them in learning the materials. These instructions were aimed at briefly informing the subjects of the role of objectives in learning. The directions used for the groups receiving objectives are reproduced in Appendix D; those used for the groups without objectives appear in Appendix E.

After reading the directions and, in the appropriate group the objectives, the student signed on to the program at the computer terminal. An A-State anxiety scale was administered before the beginning of the program. After the student had progressed through a few frames, in the objectives group, he was reminded to consult the objectives while working on the instructional program. The brief A-State anxiety scale was readministered halfway through the learning program. When the program was completed, the posttest was administered on terminal, followed by a final administration of the five item A-State anxiety scale. On this scale the subject was asked to indicate how he felt while taking the posttest, whereas the prior A-State anxiety scales, the student was asked to "Indicate how you feel right now." The bi-polar semantic differential adjective scales were then administered on the computer. The student was then signed off the terminal, and completed the second attitude scale.

RESULTS

The effects of the major independent variables, objectives, sequences, test anxiety and their interaction on posttest score, errors on program, learning time and attitude were assessed by multiple linear regression analysis. Scholastic aptitude data were available for only 74 students in the total sample; these data will, therefore, be treated separately.

Table 2 presents the regression analysis results for the major dependent variables in this study. The main effects were tested in the order in which they appear in Table 2. As expected, the main effect for objectives was not significant, while the effect for sequence was. The predicted interaction among these variables was, however, not significant. The means for these variables, presented in Table 3, indicate

that while objectives failed to exert an effect on any group, subjects taking the logical sequence had higher posttest scores than those in the scrambled sequence.

TABLE 2

Results of Regression Analysis of Dependent Variables

Variables	df	%	Posttest Variance	F[1]	%	Program Errors Variance	F	%	Time Variance	F	%	Attitude Varaince	F
Objectives (O)	1												
Sequence (S)	1		13	16.95***		15	20.09***					6	7.13**
Test Anxiety (A)	1		3	3.74		4	5.79*						
OXS	1											1	1.18
AXO	1												
AXT	1		1	1.75									
OXSXA	1		1	1.32		1	1.29		2	1.65		3	3.46

1=F values of less than 1 not shown.

*p.<.05

**p.<.01

***p<.001

TABLE 3

Means and SDs on Dependent Measures for All Groups

	Objectives				No Objectives			
	Logical		Scrambled		Logical		Scrambled	
	M	SD	M	SD	M	SD	M	SD
Posttest[1]	43.2	9.7	34.9	11.9	43.0	9.8	35.9	10.3
Program Errors	39.1	23.1	60.0	34.8	37.0	17.8	59.8	28.9
Program Time	54.7	12.7	54.9	11.2	54.4	9.6	56.8	12.2
Attitude	64.9	8.4	55.9	16.5	65.8	12.7	62.2	11.8

The data for number of errors committed on the program indicate a significant effect, see Table 2, for sequence and test anxiety. Table 3 indicates that the scrambled group committed a greater number of errors than the logically sequenced group. The main effect for test anxiety indicates that as test anxiety went up, the number of errors committed on the program also increased. There were no other significant effects for the program error data. Table 2 also indicates that there were no significant effects for time on program.

Table 2 indicates a significant effect for sequence on attitudes towards the material. Table 2 shows that, as expected, attitudes towards the program were more positive among students taking the logically sequenced material compared to those receiving the scrambled sequence. There were no other significant effects on the attitude data.

Effects on Anxiety

Measures of anxiety had been obtained at three points in the study: (1) just before the student began the program; (2) mid-way through the program; and (3) after the posttest had been completed. The means and standard deviations of these measures are presented in Table 4.

TABLE 4

Means and Standard Deviations of the Three Measures of Anxiety for Each Group

	Initial Anxiety		Mid-Program Anxiety		Post Anxiety	
Group	M	SD	M	SD	M	SD
B.O./Logical	9.8	2.8	7.4	2.7	9.3	4.0
No B.O./Logical	10.3	3.3	8.2	3.2	9.6	3.6
B.O./Random	9.8	3.7	9.2	3.8	9.9	4.0
No B.O./Random	9.5	3.1	6.7	2.3	8.9	4.3
All Subjects	9.9	3.2	7.9	3.2	9.4	3.9

The A-State data were analyzed by a 2x2x3 analysis of variance with repeated measures (A-State administrations on the last factor.)

The results obtained from this analysis appear in Table 5. The only significant effect was for the repeated factor. As can be observed from Table 4, anxiety was initially high, lower at the mid-program point, and again high during the posttest. No interactions between the main variables and the points of administration of the scale existed.

TABLE 5

Results of Repeated Measures Analysis of Variance on Anxiety

Source of Variance	df	F[1]
Objectives	1	
Sequence	1	
O x S	1	3.26
Error Between	113	
Administration	2	18.65*
O x Ad.	2	1.04
S x Ad.	2	
O x S x Ad.	2	1.92
Error Within	226	

[1] F values of less than 1 not shown

*p<.001

Effects of Interactions with Aptitude on Achievement

The effects on achievement of the interactions between objectives and aptitude, and between sequence and aptitude were evaluated by adding to the regression model containing objectives, sequence, and their interaction, three vectors representing aptitude and its first-order interactions. The analysis dealing with the second-order interaction between objectives, sequence, and aptitude involved adding this interaction vector to the full model. The appropriate reduced models were then formed and F ratios computed.

Table 6 presents the results obtained from this analysis. A strong effect on achievement was found for aptitude as a main variable ($F = 31.83$, $p < .0001$, $df = 1/69$) but no interaction effects were obtained.

TABLE 6

Results of Regression Analyses of Aptitude and Its Interactions on Posttest Data

	F	Accounted Variance	df
Aptitude (A)	31.83*	28%	1/69
A x O	1.78	2%	1/67
A x S	<1		1/67
A x O x S	<1		1/66

*$p < .0001$

Main effects for aptitude were also evident on both number of errors ($F = 18.06$; $p = .0002$, $df = 1/69$), and attitude ($F = 5.74$; $p = .018$, $df = 1/69$). An interaction between objectives and aptitude on number of errors resulted in an F of 3.63 which did not quite reach

the .05 significance level ($p = .057$, $df = 1/67$). An interaction between sequence and aptitude on learning latency also failed to reach significance ($F = 2.95$; $p = .08$, $df = 1/67$).

DISCUSSION

The results indicated that, as expected, there were no main effects attributable to objectives, and that scrambling frame sequence did reduce achievement and increase program errors. The expected interaction between objectives and sequence was not, however, obtained. Finally, test anxiety significantly affected number of errors on the program. The implications of these results will be discussed below.

Objectives

It was expected that providing students with program objectives would have no effect in the logically organized program, but that the achievement of students receiving objectives and a scrambled program should be facilitated. This interaction between objectives and sequence was not supported by the results. Evidently, objectives affected neither of the sequences significantly.

The failure of objectives to affect achievement may be related to the procedures of this experiment. Students were provided with the objectives on a xerographed sheet prior to signing on to the CAI system. They were also encouraged to review the objectives periodically while working on the CAI program. Observation of the students' behavior, however, indicated that such reviews rarely took place, if at all. Apparently the novelty, and responsiveness of the CAI system were such that students rarely bothered to return to the list of printed objectives. Confirmation for this interpretation can be found in the fact that all groups took approximately the same time on the program. If the objectives had been inspected with any frequency while the students were working on the program, time on program would have had to be longer for the objectives group.

An important suggestion for future research emerging from this study is that researchers should assure that students in fact utilize, or at least are aware of and recall, the objectives provided. This can be accomplished in a number of ways:

1) Students may be asked to recall the objectives at the end of the experiment.

2) A cloze procedure can be implemented while students read the objectives so that the researcher can infer at least that the objectives were attended to.

3) The objectives should be interspersed with the learning materials, so that the student is exposed to them during the course of instruction, and is thus able to utilize them more effectively.

4) In a CAI context, the objectives should be presented on the same medium, CRT or teletype, as is the instructional program. Such procedures are more likely to be revealing about the effectiveness of objectives than has hitherto been the case.

Sequence. The scrambled frame sequence utilized in this experiment yielded significantly more errors on acquisition, and lower achievement on posttest. These results from CAI replicate previous results in programmed instruction (Tobias, in press), and indicate that for material on which students have little 'prior' familiarity, frame sequence clearly makes the difference in the ease with which material is acquired, and how much is learned from the material.

The findings contradict those reported by Wodtke et al (1967) who found no achievement differences attributable to sequence. The materials used by Wodtke et al were also presented via CAI, and those investigators reported that 90% of the subjects employed had zero pretest scores on one of their programs. Such data would appear to contradict

the present formulation that a significant sequence effect might be expected on unfamiliar subject matter. However, two prior studies using a program of different number bases (Tobias and Weiner, 1963; Tobias & Williamson, 1968) suggest that low pretest scores do not necessarily mean little familiarity in the numbers area. Students may be unable to perform an arithmetic operation in different number bases when asked to do so on a pretest, but nevertheless often have a good understanding of the logic of different number bases. Once students are exposed to several examples of arithmetic computation in bases other than 10, familiarity with content suddenly increases dramatically. In any event, the present findings demonstrated a strong sequence effect using only technical content. Prior results (Tobias, in press) have demonstrated an even larger sequence effect for this novel content, and failed to find any effect for familiar content drawn from the same domain. These data, together with the results of other investigations summarized elsewhere (Tobias, 1972a) suggest that familiarity may be a variable of some explanatory power in instructional contexts.

Aptitude and Anxiety Data

In view of the fact that aptitude scores were missing on such a great percentage of the sample, it is difficult to interpret this data in any meaningful way. Replication of the findings with a larger N is clearly required prior to interpreting this data.

The results indicate a main effect for test anxiety on the number of errors committed on the program; however, the effect of test anxiety on posttest failed of significance. A positive relationship between program errors and test anxiety confirms a prior interpretation (Tobias, 1972b)

that students view the constructed response mode as smoething of an evaluative situation. Apparently, the fact that responses are made, and feedback then provided from the system suggests to students that it is a test-like situation rather than an instructional situation. The failure of test anxiety to exert a more prominent effect on posttest scores (it accounted for 3% of the variance but failed of significance at the .05 level) is not readily interpretable.

As to state anxiety, the present results yield only one significant effect: That of order of administrations with the posttest anxiety being high before the program, reduced at midprogram, and elevated again during posttest. This finding was to be expected, since the posttest was the most directly evaluative situation in the present experiment. The fact that state anxiety was unaffected by either objectives or sequence was unexpected. Prior research (Merrill and Towle, 1971b) had indicated that provision of objectives in a graduate course in educational research reduced state anxiety. These results were not replicated in the present experiment. Presumably, the supposition that students failed to use the objectives as effectively as they might may have limited their usefulness with respect to reducing anxiety. The failure of anxiety to be affected by sequence can be explained in terms similar to that in a previous sequence study (Tobias, in press). In order for anxiety to be elevated, the student has to describe the reasons for his poor performance to feelings of inadequacy about himself. In the scrambled conditions the material was so awkwardly arranged that it would be a rare student indeed who ascribed poor performance to himself rather than to the disorganized subject matter. Therefore, in turn, state anxiety is unlikely to be increased by such externalization.

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